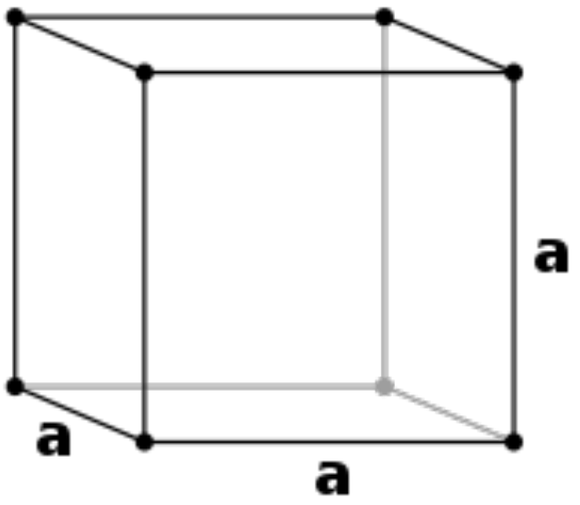
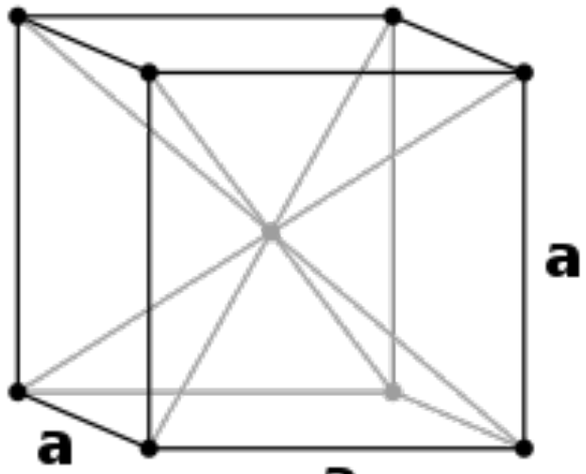
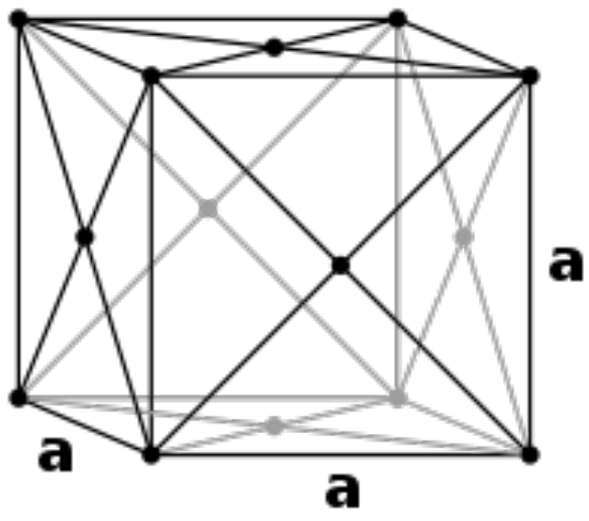
Crystals, metals and Bragg

Crystal Structure

As seen already, semiconductors (and in fact virtually all solid non-metals) exist in a repeating crystal 'lattice' structure.





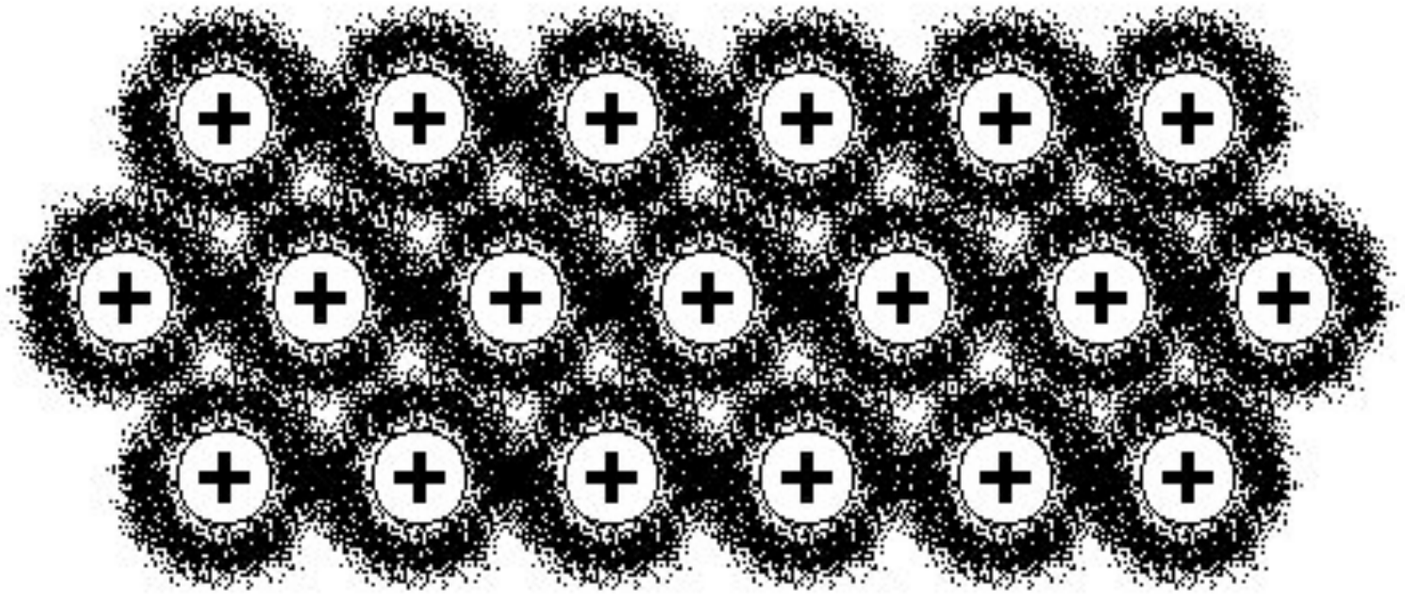


This is also the same for **metals**. They have a crystal lattice structure, but differ from non-metals in their arrangement of electrons.

http://en.wikipedia.org/wiki/Crystal_structure

Metallic structure

In metals, we consider the atoms (nuclei) to form the crystal structure, while electrons are shared.

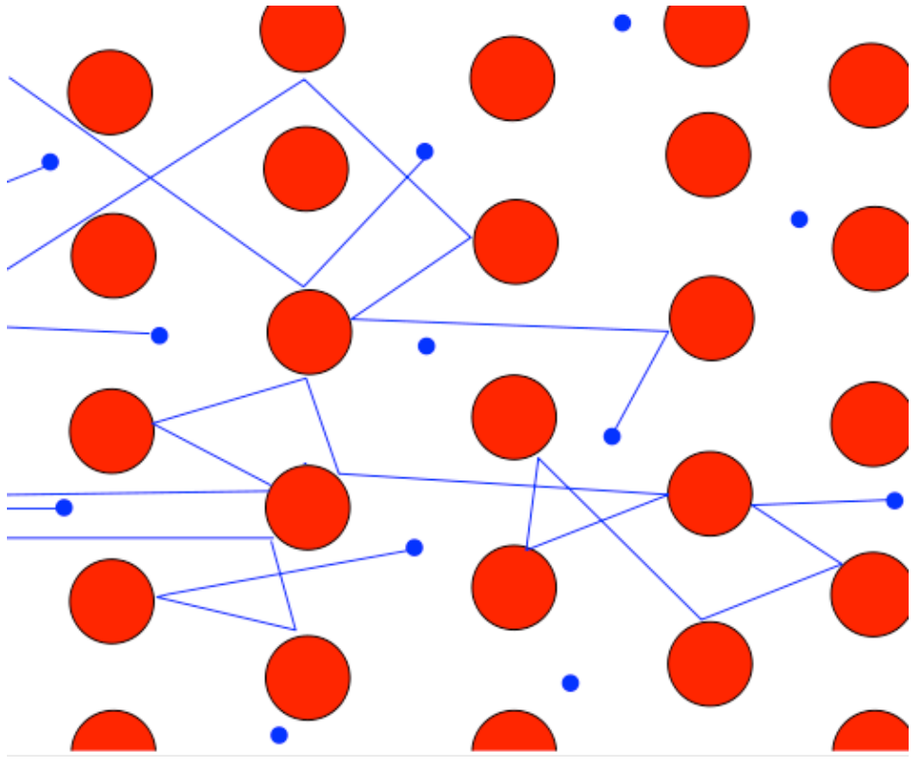


The electrons are free to move through the lattice and if no electric field is present, they move randomly through the lattice.

http://www.seas.upenn.edu/~chem101/sschem/seaelectrons.JPG

Metallic conduction

When an electric field is applied, electrons maintain their random motion but also have a net movement due to the electric field.



electron movement →

electric field ←

The flow of electrons is slowed by collisions with the nuclei

http://en.wikipedia.org/wiki/File:Electrona_in_crystallo_fluentia.svg

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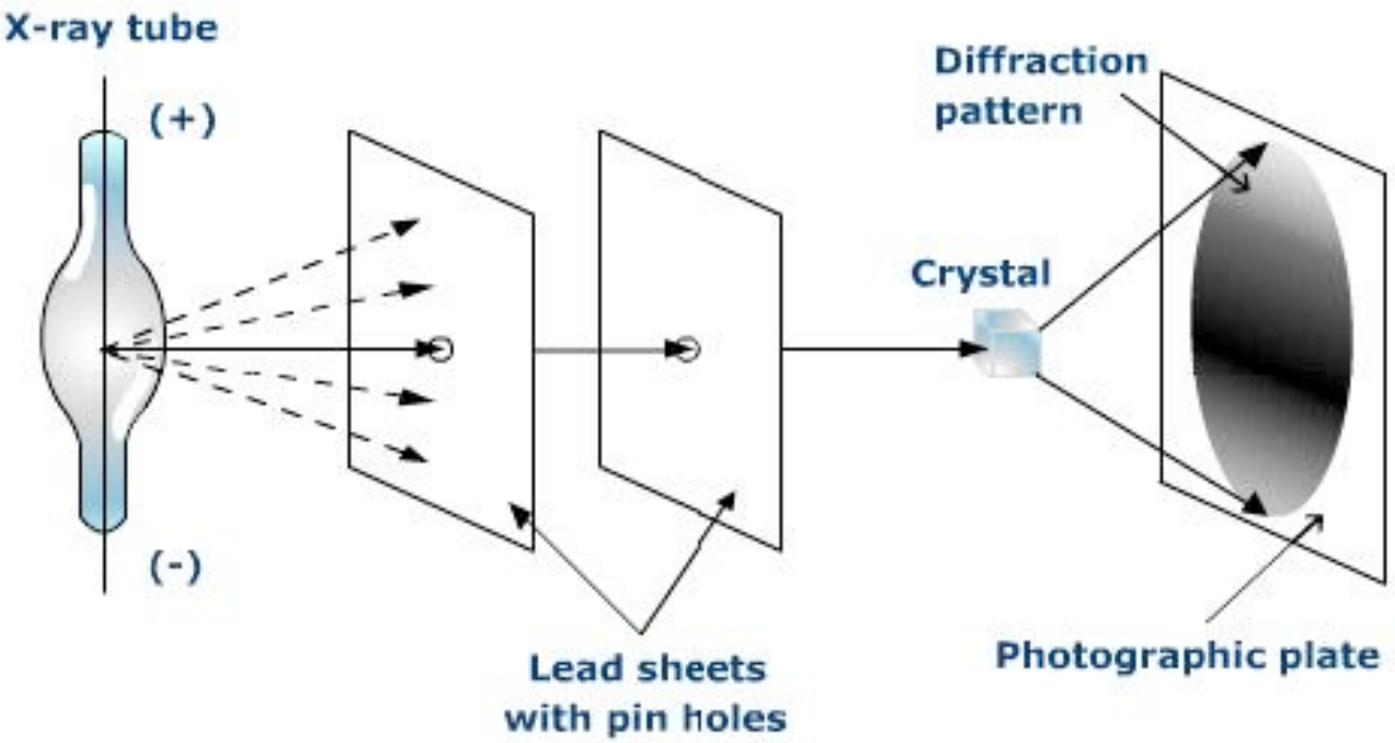
- For any non-zero temperature, the lattice structure will be vibrating due to thermal energy. The vibration will increase with temperature.
- Increased lattice vibration means that collisions between electrons and the lattice occur more frequently. This is why metals become poorer conductors as they are heated.
- If impurities are present in the metal this will also increase collisions and consequently resistance.

How do we know?

We can study crystal structure using X-RAY diffraction. X-RAY's are shone onto a crystal and they diffract to form a pattern on the other side.

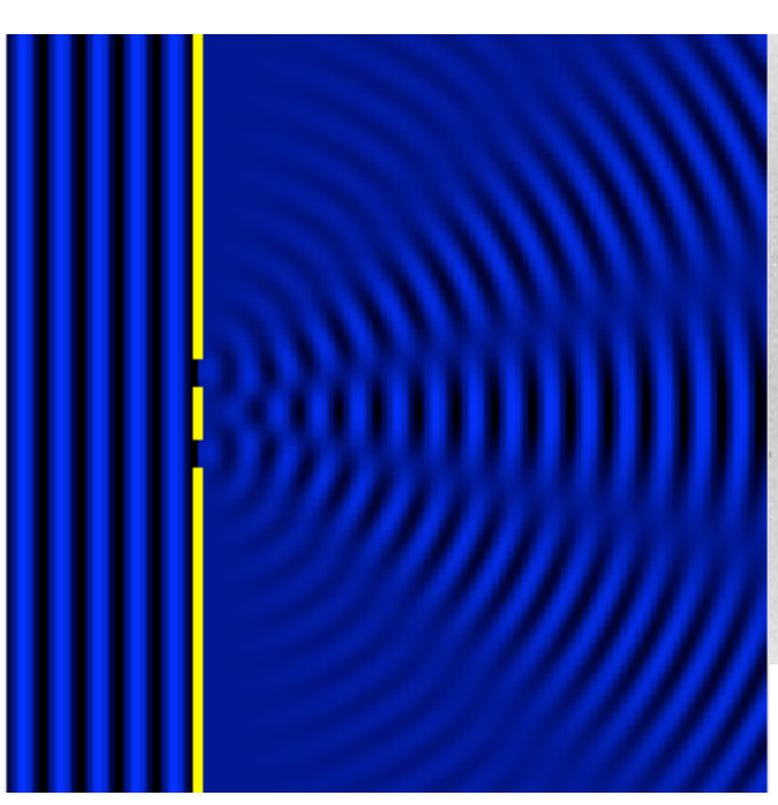
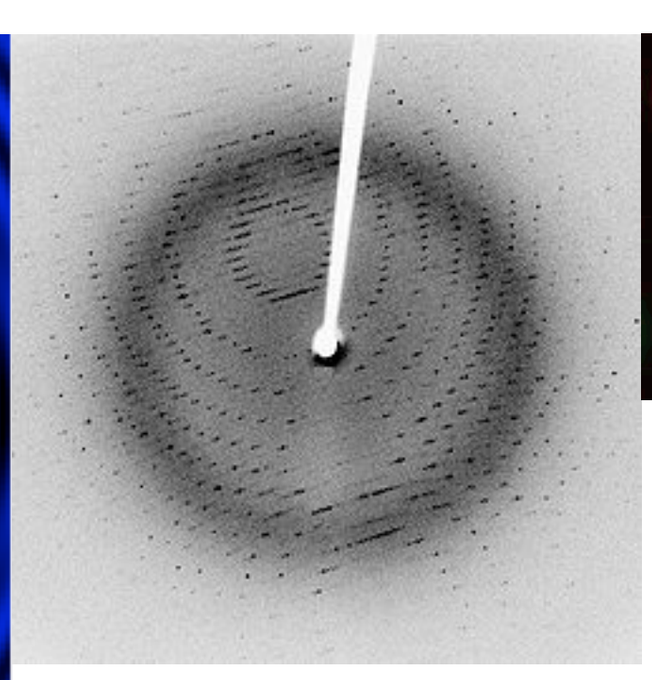
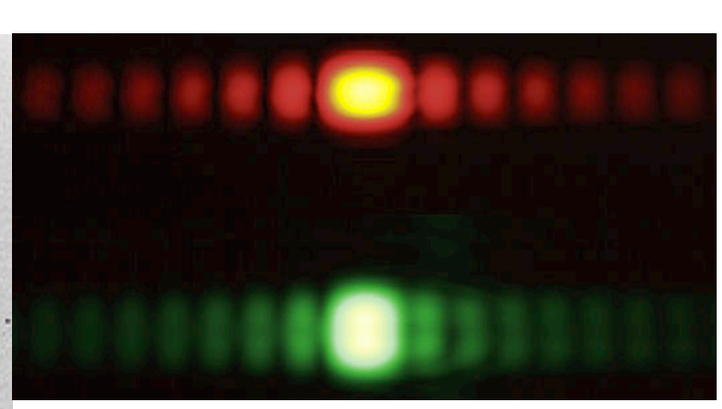


This can be used to determine the spacing and arrangement of the atoms in the crystal structure.

http://image.tutorvista.com/content/solid-state/x-ray-diffraction.jpeg

Diffraction

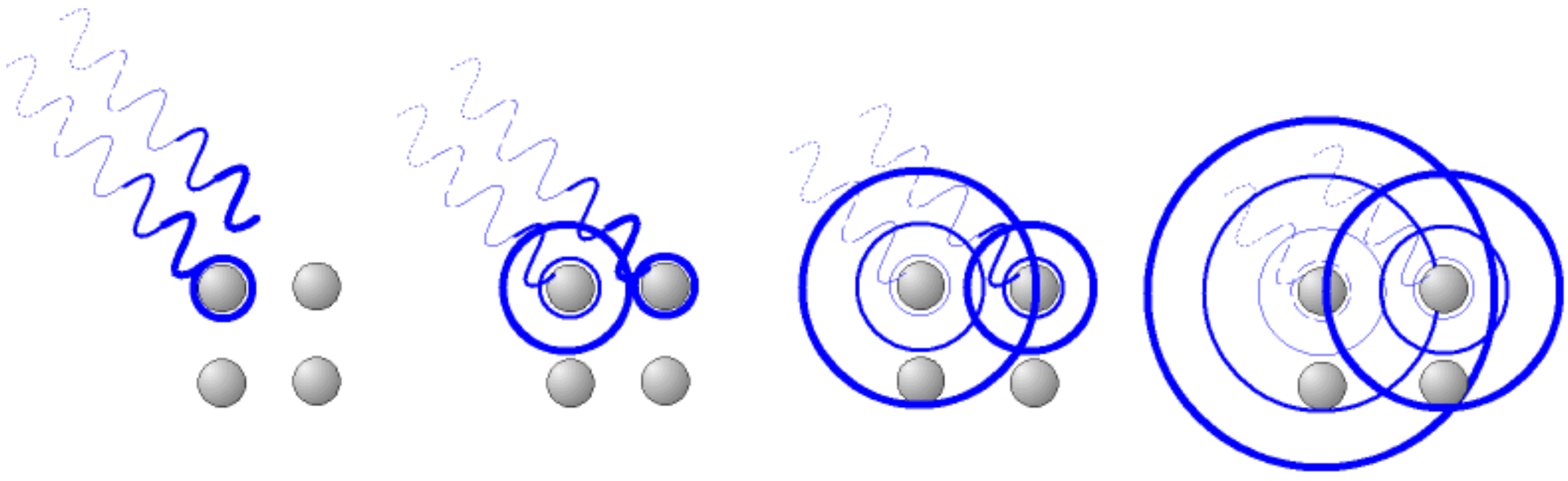
Diffraction is when a wave encounters an obstacle (or passes through a narrow slit) causing the wave to interfere with itself.

http://upload.wikimedia.org/wikipedia/commons/thumb/7/7d/X-ray_diffraction_pattern_3clpro.jpg/250px-X-ray_diffraction_pattern_3clpro.jpg
http://www.sciencephoto.com/image/157193/530wm/C0094580-Diffraction_on_a_Slit-SPL.jpg
http://upload.wikimedia.org/wikipedia/commons/a/a9/Doubleslit.gif

The Bragg's

- The use of X-RAY diffraction to study crystal structure was pioneered by William and William Bragg (British father and Australian born son).
- They proposed that the wavelength of X-RAYs would be ideal to create useful diffraction patterns with atomic crystal structures.



http://upload.wikimedia.org/wikipedia/commons/0/0c/Diffusion_rayleigh_et_diffraction.png

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- They discovered that the diffraction through solids caused interesting patterns (as opposed to the pattern produced by liquids).
- They proposed an equation in 1913 (now known as Bragg's law) which relates the distance between diffraction peaks and the atomic crystal spacing:

$$n\lambda = 2dsin\theta$$

http://en.wikipedia.org/wiki/File:William_Henry_Bragg_2.jpg
http://en.wikipedia.org/wiki/File:WI-bragg.jpg